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DYNAMICS OF PASSERINE MIGRATION IN VERACRUZ, MÉXICO

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Abstract. The state of Veracruz, along the gulf coast of México, is an important flyway for Neotropical migrants. Many passerines and other land birds use remnants of native vegetation as stopover sites for shelter and refueling during their migration. We operate a long-term banding station in a coastal forest near the fishing village of Playa Salinas, in the municipality of Alvarado, with the purpose of studying patterns of spring migration. After nine seasons of mist-netting and banding, we recorded 77 species of birds using this site as regular northward transients and have banded nearly 1000 individuals per season. The majority of the records (41.9% of the total), are from six species: Least Flycatcher (*Empidonax minimus*), Yellow Warbler (*Dendroica petechia*), Swainson's Thrush (*Catharus ustulatus*), Gray Catbird (*Dumetella carolinensis*), Yellow-breasted Chat (*Icteria virens*), and Wilson's Warbler (*Wilsonia pusilla*). We provide some notes on the timing of their migration and annual capture rates. Multiple-year recaptures of banded individuals are low (37 individuals of 10 species, from a total of 8479 individuals banded in the period 1999-2007). Recaptures ranging from 2-8 years (mean 2.9 years) show either low site fidelity or low interannual survivorship. Our banding station is one of the longest-running operations in Latin America. Its results provide important data on the ecology of passerine migration and contribute to the conservation of stopover habitats for transient and winter residents.

Keywords: Passerines, spring migration, Veracruz, Mexico, stopover ecology, banding station.

DINÁMICA DE LA MIGRACIÓN DE PASERINAS EN VERACRUZ, MÉXICO

Resumen. El estado de Veracruz, a lo largo de la costa del Golfo de México, es una importante ruta para migratorias neotropicales. Muchas paserinas y otras aves terrestres usan los remanentes de vegetación como sitios de descanso, alimentación y protección durante su migración. Operamos una estación de anillado de largo plazo en un bosque costero cerca de la communidad de Playa Salinas, en el municipio de Alvarado, con el propósito de estudiar patrones de migración. Después de nueve temporadas de captura y anillado, hemos registrado 77 especies de aves usando este sitio regularmente en su camino al norte y hemos anillado cerca de 1000 individuos por temporada. La mayoría de los registros (41.9 % del total) pertenecen a 6 especies: *Empidonax minimus, Dendroica petechia*, *Catharus ustulatus, Dumetella carolinensis, Icteria virens*, y *Wilsonia pusilla*. Aquí aportamos algunas notas sobre la temporalidad de su migración y tasas anuales de captura. Las recapturas de individuos en múltiples años son pocas (37 individuos de 10 especies, de un total 8479 individuos anillados en el periodo 1999-2007). Las recapturas varían de 2 a 8 años (media 2.9 años) y muestran poca fidelidad de sitio o baja sobrevivencia interanual Nuestra estación es una de las más antiguas en operación en Latinoamérica. Los resultados proveen de datos importantes sobre la ecología de la migración de paserinas y contribuye a la conservación de hábitats de reabastecimiento para migratorias de paso y residentes invernales.

INTRODUCTION

Veracruz is well-known as an important flyway for migratory bird species (Rappole and Ramos 1994, Ruelas et al. 2005). Two hundred thirty six of 689 species registered for the state (Martínez-Gómez 1996), are transients or winter residents that use different habitats along the Gulf of Mexico migration route (Warnock and Bishop, 1998, Barrow et al. 2005, Ruelas et al. 2005).

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The conservation needs of migrants have dictated the agenda of stopover ecology research (Lindstrom, 1995, Moore 2000, Mehlman et al. 2005). The rate of loss and the dynamics of habitats available for migrants en route make the basic step of determining the presence of species, quantifying the magnitude of the populations using local stopover habitats, and understanding the role of habitats in migrant bird ecology (Moore et al. 1993, 2005, Yong et al. 1998, Woodrey et al. 2005) a focus in migration stopover research.

Key questions include: 1) How diverse is the assemblage of migratory land birds in the Gulf of Mexico spring flyway? 2) Are there species or populations of special concern among the birds regularly recorded there? 3) Are these populations constant among years or is there high interannual variation? 4) What is the phenology of their migrations? 5) Are these temporal patterns constant or variable among years? 6) Are there new insights into migrant-bird/local-habitat relationships emerging from our study site? In order to answer these questions, Pronatura Veracruz has operated a bird banding station since the spring of 1999 along the Gulf Coast of Veracruz, México.

In this paper, we describe the general patterns of passerine migration recorded from a banding station in the small coastal village of Playa Salinas, near the city of Alvarado, Veracruz. We list the species recorded through the operation of mist nets, quantify their capture rates, provide some measures of interannual variation, and report simple survivorship estimates from recaptured individuals. We also highlight other important findings based on band recoveries such as records of species new for the region and the state.

METHODS

Habitats around the Banding Station

The Playa Salinas Banding Station (PSBS) operates within fragmented remnants of tropical deciduous forest and coastal oak savanna with a predominance of trees from the genus *Quercus*, *Coccoloba*, and the palm *Sabal mexicana*. Understory is dominated by species of the Bromeliaceae family, specially the Pinguin bromeliad (*Bromelia pinguin*), and second-growth shrubs.

Mist-Net Array and Seasonality of Operations

PSBS operates 20 mist-nets (2.5 by 12 m, 25 mm mesh), placed in a permanent circuit of 15 sites, with a small processing station located at the center of the circuit. Nets stay open 07:00-12:00 CST, close during the hours of intense heat, and open again the late afternoon 17:00-19:30.

PSBS operates annually from mid-April to late-May, during the height of spring migration in Veracruz (about 15 April to 30 May). During the first season of banding in 1999, the station operated for a shorter season, only until early May, because it was at in an experimental stage (5 April to 3 May). We placed US Fish and Wildlife Service aluminum bands on all migratory species except for the Ruby-throated Hummingbird (for all scientific names of bird species, see Table 1), because they require special bands and techniques for their marking.

RESULTS

Species Present and Relative Abundance in the Veracruz Assemblage

During the spring field seasons 1999-2007, a total of 8479 individuals (77 species of 16 families, Table 1), were captured and banded at PSBS. The species most commonly captured were Least Flycatcher (11.3% of captures), Yellow Warbler (11.1%), Swainson's Thrush (6.1%), Gray Catbird (5.6%), Yellow-breasted Chat (4.1%) and Wilson's Warbler (3.7%) (Table 1).

PSBS samples mostly passerines, and the families with the largest number of species represented were Parulidae (39.3% of captures), Tyrannidae (29.4%) and Vireonidae (5.3%). Unidentified *Empidonax* species belonging to the Traill's/Alder Flycatcher "complex" accounted for 5.4% of all captures. Because species-level identification was not attempted during the 2002-2005 seasons for any problematic *Empidonax*, the percentage of captures for that genus is higher for that period, with the category "unidentified flycatcher" accounting for 8.9% of all captures during those years.

Capture Rates and Other Measures from Mist-Net Samples

Captures per season varied greatly for a constant site, from 448-1428 birds per field season (mean of 947 captures). The seasonal mean capture rate had over a three-fold interannual variation, from 8.4 to 29.1 birds per day of standard operation (Table 2). The taxonomic make-up of the samples, however, remained relatively constant: the number of species sampled annually varied from a low of 47 (in 2000) to an atypical maximum of 77 (in 2007) (mean 54 species) (Table 2); the diversity of families sampled per field season did not vary significantly among years (10-13 families).

TABLE 1. Species and families of neotropical migrants captured during spring migration at the Playa Salinas Banding Station, Alvarado, Veracruz, México, 1999–2007.

Species		Year									
		1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Kites, hawks, and eagles (Accipitridae 1)											
Sharp-shinned Hawk	*Accipiter striatus*	1	1	0	0	0	0	0	0	0	2
Cuckoos, roadrunners, and anis (Cuculidae 2)											
Black-billed Cuckoo	*Coccyzus erythrophtalmus*	0	0	1	0	0	0	0	0	1	2
Yellow-billed Cuckoo	*Coccyzus americanus*	0	0	4	1	0	1	0	0	1	7
Nighthawks (Caprimulgidae 1)											
Lesser Nighthawk	*Chordeiles acutipennis*	0	0	0	0	0	0	0	3	0	3
Hummingbirds (Trochilidae 1)											
Ruby-throated Hummingbird	*Archilocus colubris*	4	3	44	9	31	50	18	71	13	243
Woodpeckers (Picidae 1)											
Yellow-bellied Sapsucker	*Spyrapicus varius*	0	0	0	0	1	0	0	0	1	2
Flycatchers (Tyrannidae 15)											
Olive-sided Flycatcher	*Contopus cooperii*	0	0	0	0	0	0	0	2	2	4
Western Wood-pewee	*Contopus sordidulus*	0	0	0	0	4	0	0	0	0	4
Eastern Wood-pewee	*Contopus virens*	1	3	1	6	2	2	1	17	16	49
Yellow-bellied Flycatcher	*Empidonax flaviventris*	2	21	22	5	12	11	12	30	37	152
Acadian Flycatcher	*Empidonax virescens*	0	0	2	0	0	0	0	0	0	2
Alder Flycatcher	*Empidonax alnorum*	11	42	27	0	0	0	0	134	230	444
Willow Flycatcher	*Empidonax traillii*	2	18	87	0	1	0	0	123	80	311
Least Flycatcher	*Empidonax minimus*	67	77	45	75	235	52	167	156	87	961
Buff-breasted Flycatcher	*Empidonax fulvifrons*	0	0	0	0	0	1	4	1	3	9
Unidentified Flycatcher	*Empidonax* sp	0	13	18	58	202	88	63	6	8	456
Great-crested Flycatcher	*Myiarchus crinitus*	1	4	2	0	9	7	12	6	4	45
Brown-crested Flycatcher	*Myiarchus tyrannulus*	1	0	0	1	0	0	0	0	23	25
Western Kingbird	*Tyrannus verticalis*	0	0	0	0	0	0	1	2	1	4
Eastern Kingbird	*Tyrannus tyrannus*	1	0	0	1	0	1	1	2	4	10
Scissor-tailed Flycatcher	*Tyrannus forficatus*	2	0	1	5	3	0	0	10	0	21
Vireos (Vireonidae 7)											
White-eyed Vireo	*Vireo griseus*	1	0	6	0	12	8	3	1	3	34
Bell's Vireo	*Vireo bellii*	0	0	0	1	1	0	1	4	2	9
Yellow-throated Vireo	*Vireo flavifrons*	1	1	2	0	0	2	2	3	2	13
Blue-headed Vireo	*Vireo solitarius*	1	4	2	0	7	2	5	7	3	31
Warbling Vireo	*Vireo gilvus*	0	2	2	0	8	3	12	15	2	44

TABLE 1. CONTINUED.

Species		Year									
		1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Philadelphia Vireo	*Vireo philadelphia*	7	19	1	5	3	5	0	2	10	52
Red-eyed Vireo	*Vireo olivaceus*	9	10	29	40	30	21	21	67	40	267
Swallows (Hirundinidae 1)											
Barn Swallow	*Hirundo rustica*	0	0	2	0	0	1	0	1	0	4
Wrens (Troglodytidae 1)											
House Wren	*Troglodytes aedon*	1	6	2	0	2	0	0	0	0	11
Trushes and allies (Turdidae 4)											
Veery	*Catharus fuscescens*	1	0	1	0	2	12	14	8	3	41
Hermit Thrush	*Catharus minimus*	9	2	7	8	2	13	28	9	12	90
Swainson's Thrush	*Catharus ustulatus*	43	47	17	21	107	88	56	39	102	520
Wood Thrush	*Hylocichla mustelina*	4	3	0	0	0	7	6	0	3	23
Mockingbirds and thrashers (Mimidae 1)											
Grey Catbird	*Dumetella carolinensis*	51	59	59	6	59	65	54	46	74	473
Wood-Warblers (Parulidae 29)											
Blue-winged Warbler	*Vermivora pinus*	0	0	0	0	0	4	2	1	1	8
Golden-winged Warbler	*Vermivora chrysoptera*	0	0	0	0	1	0	0	0	0	1
Tennessee Warbler	*Vermivora peregrina*	25	5	32	18	14	104	13	24	16	251
Orange-crowned Warbler	*Vermivora celata*	0	2	3	0	2	2	0	0	0	9
Nashville Warbler	*Vermivora ruficapilla*	2	2	1	1	2	18	8	7	3	44
Northern Parula	*Parula americana*	1	0	1	0	4	6	0	0	1	13
Yellow Warbler	*Dendroica petechia*	82	93	78	56	93	87	93	202	153	937
Chestnut-sided Warbler	*Dendroica pensylvanica*	1	1	5	4	5	13	7	8	21	65
Magnolia Warbler	*Dendroica magnolia*	15	18	30	24	38	26	38	67	43	299
Black-throated Green Warbler	*Dendroica virens*	3	1	2	1	9	5	4	7	9	41
Townsend's Warbler	*Dendroica townsendi*	0	0	0	0	0	1	0	1	0	2
Blackburnian Warbler	*Dendroica fusca*	0	0	2	0	2	1	0	1	1	7
Bay-breasted Warbler	*Dendroica castanea*	0	1	0	1	0	8	1	1	3	15
Blackpoll Warbler	*Dendroica striata*	0	0	1	0	0	0	0	0	0	1
Black-and-white Warbler	*Mniotilta varia*	2	4	5	2	13	6	6	10	7	55
American Redstart	*Setophaga ruticilla*	1	5	4	11	10	16	14	17	22	100
Prothonotary Warbler	*Protonotaria citrea*	1	2	0	0	0	1	0	0	0	4
Worm-eating Warbler	*Helmitheros vermivorus*	1	0	1	0	1	2	4	1	2	12
Swainson's Warbler	*Limnothlypis swainsonii*	0	0	0	0	0	2	0	0	0	2
Ovenbird	*Seiurus aureocapillus*	5	11	7	4	13	6	17	7	8	78

TABLE 1. CONTINUED.

Species		Year									
		1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Northern Waterthrush	*Seiurus noveboracensis*	4	5	11	2	6	7	10	12	6	63
Kentucky Warbler	*Oporornis formosus*	0	0	4	0	1	6	1	1	3	16
Mourning Warbler	*Oporornis philadelphia*	3	9	19	11	39	8	11	65	47	212
MacGillivray's Warbler	*Oporornis tolmiei*	2	2	5	3	5	3	10	11	9	50
Common Yellowthroat	*Geothlypis trichas*	10	17	33	27	27	29	29	34	57	263
Hooded Warbler	*Wilsonia citrina*	1	1	1	0	6	7	5	2	3	26
Wilson's Warbler	*Wilsonia pusilla*	28	30	9	16	50	30	65	48	41	317
Canada Warbler	*Wilsonia canadensis*	6	17	9	3	11	1	11	20	14	92
Yellow-breasted Chat	*Icteria virens*	27	46	26	5	50	60	72	21	42	349
Tanagers (Thraupidae 3)											
Summer Tanager	*Piranga rubra*	6	0	4	0	1	14	1	2	2	30
Scarlet Tanager	*Piranga olivacea*	2	1	1	0	0	4	2	0	0	10
Western Tanager	*Piranga ludoviciana*	0	0	0	0	0	0	1	0	0	1
Brushfinches, seedeaters, sparrows, and allies (Emberizidae 3)											
Savanna Sparrow	*Ammodramus savannarum*	0	0	2	0	0	0	2	2	0	6
Song Sparrow	*Melospiza melodia*	0	0	0	0	0	1	0	0	0	1
Lincoln's Sparrow	*Melospiza lincolnii*	0	11	1	1	1	0	11	3	5	33
Cardinals, grosbeaks, and allies (Cardinalidae 5)											
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	1	0	0	0	1	1	1	0	2	6
Blue Grosbeak	*Passerina caerulea*	1	0	0	0	0	0	0	0	0	1
Indigo Bunting	*Passerina cyanea*	14	15	25	1	19	89	9	11	10	193
Painted Bunting	*Passerina ciris*	8	20	16	6	21	43	19	37	18	188
Dickcissel	*Spiza americana*	1	4	0	0	0	0	0	0	0	5
Blackbirds and orioles (Icteridae 2)											
Orchard Oriole	*Icterus spurius*	23	6	13	2	12	97	2	17	3	175
Baltimore Oriole	*Icterus galbula*	6	2	69	1	15	16	0	20	1	130

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TABLE 2. VARIATION IN CAPTURE RATES OF NEOTROPICAL MIGRANTS DURING SPRING MIGRATION AT THE PLAYA SALINAS BANDING STATION IN VERACRUZ, MÉXICO, 1999-2007.

Year	Number of species	Number of families	Number of individuals	Capture rate (mean birds day^{-1})
1999	51	11	503	9.5
2000	47	12	669	12.6
2001	54	13	807	15.2
2002	40	10	448	8.4
2003	54	12	1,219	23.0
2004	57	12	1,174	22.1
2005	51	10	955	18.0
2006	57	12	1,428	27.3
2007	77	12	1,323	29.1

The highest capture rates were those for Least Flycatcher and Yellow Warbler, while the Magnolia Warbler was the species with the highest recovery rates.

INTERANNUAL SURVIVORSHIP

PSBS has had few recaptures (in different years) of individuals banded at this station: 37 individuals of 10 species (Table 3). These individuals, with two or more of such recoveries, show life-spans ranging 2-8 years (mean of 2.9 years, Table 3). Noteworthy examples of these are a Magnolia Warbler that was consecutively recaptured for six years and a Tennessee Warbler originally banded in 2000 and recaptured in 2007.

SEASONAL VARIATION IN CAPTURE RATES

Daily capture rates peaked around the end of April, with smaller capture peaks during May. These "peaks" normally occurred after rainy days or other climatic conditions adverse for migration.

NEW DISTRIBUTIONAL RECORDS

Townsend's Warbler and Western Kingbird were new regional records for the coastal region of central Veracruz.. The Townsend's Warbler is usually found in winter in the oak-pine forest of the mountains whereas the Western Kingbird is a resident of west and central Mexico. Both species have been recorded as vagrants in the Sierra de Los Tuxtlas region in south Veracruz (Howell and Webb 1995).

DISCUSSION

DIVERSITY AT PSBS

The diversity of species and families, and the capture rates of individuals from PSBS are comparable to those of other studies (for a summary, see Wang and Finch 2002). The measure of relative abundance provided by our mist-net data should be interpreted with caution since mist-net samples provide a biased measure of abundance (Wang and Finch 2002).

INTERANNUAL VARIATION IN CAPTURE RATES

The variation in the capture rates for the most common species is significant among seasons. Although it has been suggested in principle that capture rates can be used as a measure of change in population levels (e.g., Dunn et al. 2004), we did not address the topic in this paper. Simons et al. (2004) identified many elements that influence the variation in capture rates, such as weather rhythms, habitat changes and other factors. More recently, Hochachka and Fiedler (2008) identified that a trend in "trappability" can affect these estimates. We will explore this issue in the future, when our understanding of factors affecting capture rates allows us to calculate population change using an appropriate analysis model that accounts extrinsic sources of variation.

VALUE OF HABITATS SURROUNDING BANDING STATION AS STOPOVER HABITAT

Although this paper does not cover the topic of mass gains and dietary preferences of migrants while using the habitats around PSBS, our observations while banding migrants suggest that migrants are frequently using fruits of the two most common fruiting trees (*Coccoloba humboldtii* and *C. barbadensis*). Many of the species captured, including some typically considered insectivores such as wood-warblers and flycatchers, left (*Coccoloba*?) droppings in fabric bags, at the base of the nets, or in the processing station while being banded.

TABLE 3. INTERANNUAL SURVIVORSHIP OF 37 INDIVIDUALS (10 SPECIES) OF SPRING MIGRANTS CAPTURED AT THE PLAYA SALINAS BANDING STATION IN VERACRUZ, MEXICO, 1999-2007.

Species	Band number	1999	2000	2001	2002	2003	2004	2005	2006	2007
Least Flycatcher	2180-35096	0[a]	1	1	0	0	0	0	0	0
	2190-76049	0	0	1	1	0	0	0	0	0
	2270-35078	0	0	0	0	1	0	1	0	1
	2350-99339	0	0	0	0	0	1	1	0	1
Yellow-throated Vireo	2070-98223	1	1	0	0	0	0	0	0	0
Gray Catbird	0941-58310	0	1	1	0	0	0	0	0	0
	0941-58324	0	1	0	0	1	1	0	0	0
	1411-19684	0	1	0	0	1	0	0	0	1
House Wren	2070-97551	0	1	0	0	1	0	0	0	0
Tennessee Warbler	2180-35051	0	1	0	0	0	0	0	0	1
	2180-35883	0	0	0	1	1	0	0	0	0
Yellow Warbler	2110-91210	1	0	1	0	0	0	0	0	0
	2110-91236	1	1	0	0	0	0	0	0	0
	2110-91295	1	0	1	0	0	0	0	0	0
Magnolia Warbler	2110-91202	1	1	0	0	0	0	0	0	0
	2110-91207	1	0	1	0	0	0	0	0	0
	2110-91211	1	1	1	1	1	1	0	0	0
	2180-35092	0	1	1	0	0	0	0	0	0
	2180-35094	0	1	1	0	0	0	0	0	0
	2180-35809	0	0	0	1	0	1	0	0	0
	2180-35951	0	0	0	0	1	1	1	0	0
	2180-35952	0	0	0	0	1	1	0	0	0
	2180-35973	0	0	0	0	1	1	0	0	0
	2300-75702	0	0	0	0	1	1	0	0	0
Ovenbird	1671-29027	0	0	0	1	0	0	1	0	0
	1671-29030	0	0	0	1	1	0	0	0	0
	1671-29089	0	0	0	0	1	1	0	0	0
	1911-11703	0	0	0	0	0	1	1	0	0
	2070-98201	1	1	0	0	0	0	0	0	0
Black and White Warbler	2110-91209	1	1	0	0	0	0	0	0	0
	2270-35075	0	0	0	0	1	1	0	0	1
Yellow-breasted Chat	1411-19670	0	1	1	0	0	0	0	0	0
	1411-19671	0	1	1	0	0	0	0	0	0
	1411-19947	0	0	0	0	1	0	1	0	0
	1411-19948	0	0	0	0	1	0	1	0	0
	1411-19961	0	0	0	0	1	1	0	0	0
	1711-72062	0	0	0	0	0	1	1	0	0

[a] 0 = individual was not captured in that year; 1 = individual was captured in that year

CONCLUDING REMARKS

The results obtained from the banding at PSBS show the importance of this site as a migratory stopover habitat for neotropical migrants. The diversity and abundance of species banded give this site great conservation relevance in a landscape of steadily declining stopover habitat.

The abundance of fruits during the passage of spring migrants may also indicate that birds are important dispersers for the seeds of the *Coccoloba* and other plant species, but more studies are needed in this specific matter to accurately prove this hypothesis.

Given this loss of habitat, we hope to be able in a near future to include this area in some category of protection, either state or private, and continue and expand our research for many more years.

Since the PSBS is located in the IBA C-50 (Humedales de Alvarado), this study contributes to our knowledge on the importance of this area as part of this bird protection scheme. Besides that, Pronatura Veracruz is also increasing its presence with more studies of the aquatic birds of this area, both migratory and resident.

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